Tests of Light Output vs. WLS Fiber Diameter

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This is a compilation of some measurements done at the University of Minnesota and Caltech. The Caltech data are taken from NUMI note 414, published with this document. The dependence of light output from the WLS fiber is best fit by a parabola.

Measurements

The Caltech measurements are described in NUMI 414, posted with this NOvA Note, and will not be repeated here. The tests done at the University of Minnesota were done with a small area liquid scintillator cell of approximately 25mmx25mm cross section. A single fiber was inserted into the cell and the light output of through-going cosmic ray air shower particles was measured. The mean light output for each fiber was used as the measure of the light collection of that fiber. Fibers of different diameters were used. The results are tabulated below, shown relative to the 1.0mm fiber:

Fiber Diameter(mm)	Relative light output
0.25	0.12
0.50	0.44
0.75	0.64
0.83	0.74
0.83	0.73
1.00	1.01
1.00	0.99
1.20	1.17
1.20	1.17

Multiple measurements of some fiber diameters were used, as indicated in the table, and are simply averaged for the fits.

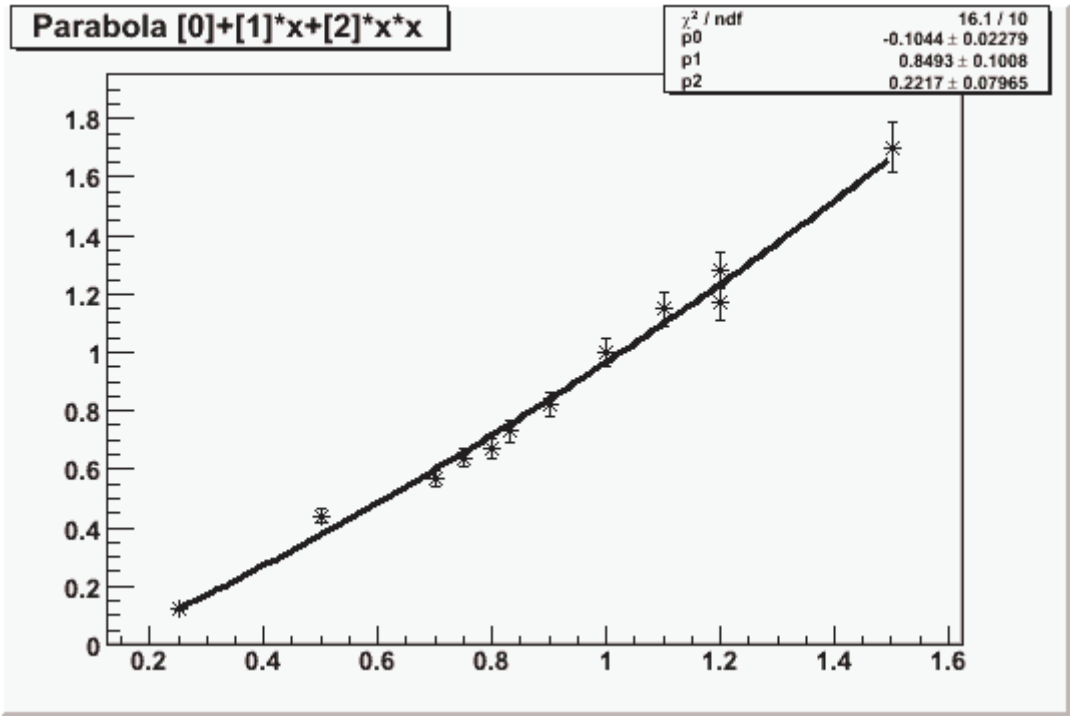
The Caltech data are tabulated below:

Fiber Diameter(mm)	Relative light output
0.70	0.57
0.80	0.67
0.90	0.82
1.00	1.00
1.10	1.14
1.20	1.31
1.50	1.74

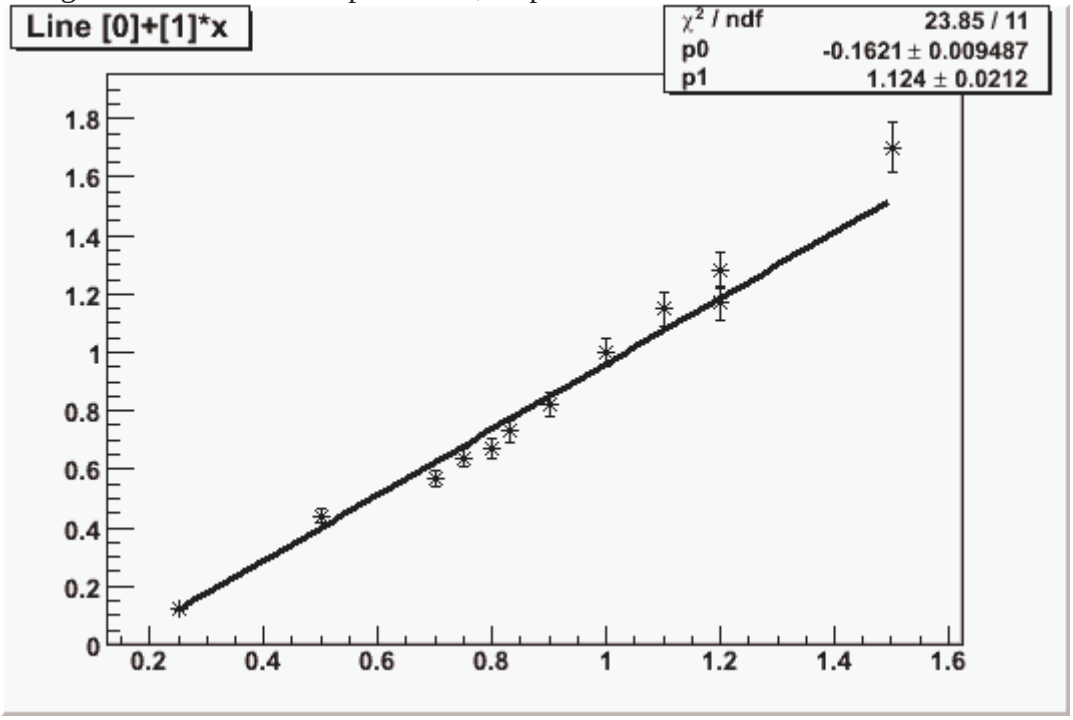
Polynomial and power law fits assuming a 5% error were made to the combined data from the University of Minnesota and Caltech measurements. A parabolic equation, $-0.1+0.85x+0.22x^2$ was found to be the best. The best power law fit without any offset had a power law index of 1.4, in agreement with the result reported in NUMI-414. A better fit, and a smaller index of 1.2, was found when the offset was allowed to vary. A straight line fit over the whole range was not a particularly good fit, since it overestimated the slope at small diameters and underestimated it at higher values of the diameter. The fit parameters and graphical results are shown below, along with the ROOT code used to produce them.

Fit results:

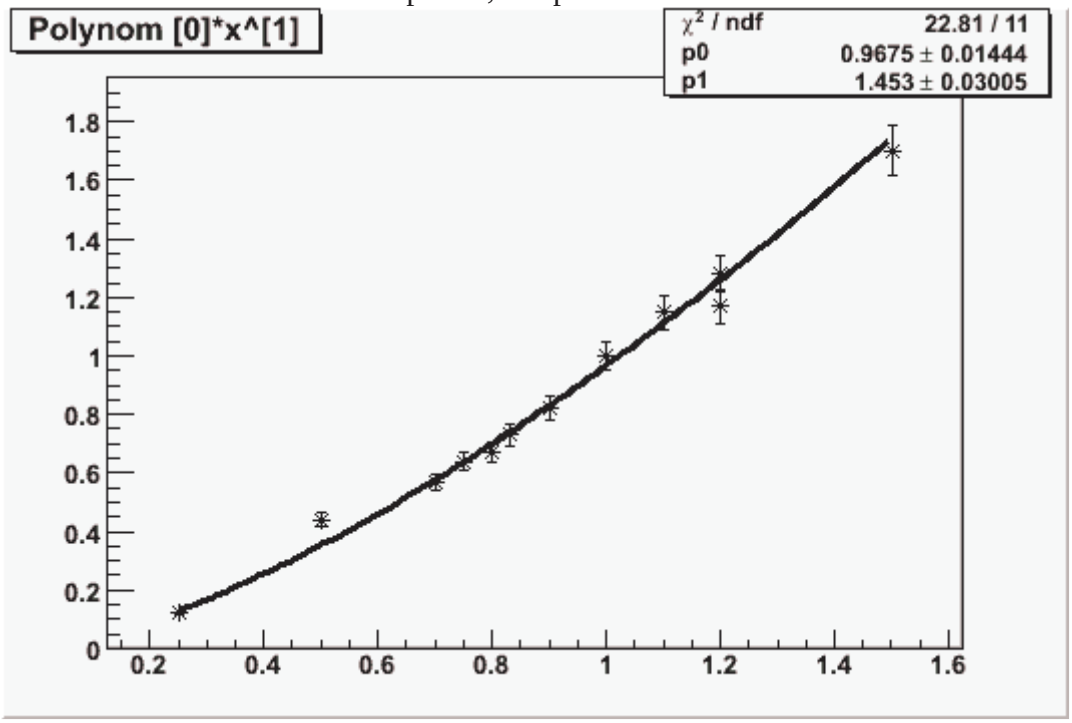
Parabolic fit to data. –Best fit.



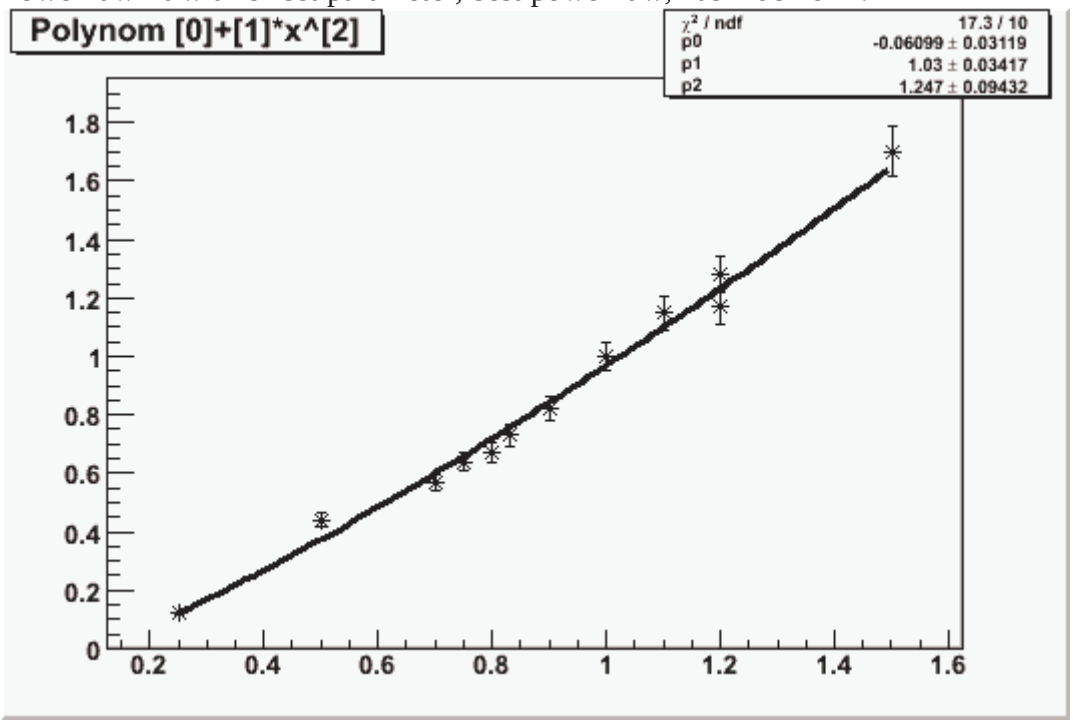
Straight line fit with offset parameter, slope is 1.12.



Power law fit with fixed intercept at 0, has power law index of 1.5.



Power law fit with offset parameter, best power law, has index of 1.2



Appendix A Code used to produce plots

The Function below was used in ROOT to produce the plots. It includes the data from CIT and UMN studies.

```
{
  Double_t DIAMcit[7]={0.7,0.8,0.9,1.0,1.1,1.2,1.5};
  Double_t LOcit[7]={0.57,0.67,0.82,1.0,1.15,1.28,1.70};
  Double_t DIAMumn[6]={0.25,0.5,0.75,0.83,1.0,1.2};
  Double_t LOumn[6]={0.12,0.44,0.64,0.73,1.0,1.17};
  Double_t Diam[13]={0.7,0.8,0.9,1.0,1.1,1.2,1.5,
                     0.25,0.5,0.75,0.83,1.0,1.2};
  Double_t LO[13]={0.57,0.67,0.82,1.0,1.15,1.28,1.70,
                   0.12,0.44,0.64,0.73,1.0,1.17};
  Double_t dLO[13];
  gStyle->SetOptFit(1);
  for (Int_t i=0;i<13;i++) dLO[i]=0.05*LO[i];
  TGraphErrors *LOgraph = new TGraphErrors(13,Diam,LO,0,dLO);
  LOgraph->Draw("AW*");
  LOgraph->GetHistogram()->SetTitle("Line, force zero [0]*x");
  gStyle->SetOptStat(1);
  TF1 *myp1 = new TF1("myp1","[0]*x",0,2);
  LOgraph->Fit(myp1);
  c1->Print("1paramline.gif");
  LOgraph->GetHistogram()->SetTitle("Line [0]+[1]*x");
  TF1 *myp1 = new TF1("myp1","[0]+[1]*x",0,2);
  LOgraph->Fit(myp1);
  c1->Print("2paramline.gif");
  LOgraph->GetHistogram()->SetTitle("Parabola [0]+[1]*x+[2]*x*x");
```

```
  TF1 *myp1 = new TF1("myp1","pol2",0,2);
  LOgraph->Fit(myp1);
  c1->Print("parabola.gif");
  TF1 *mypol = new TF1("mypol","[0]*x^[1]",0,2);
  LOgraph->GetHistogram()->SetTitle("Polynom [0]*x^[1]");
  LOgraph->Fit(mypol);
  c1->Print("2parampoly.gif");
  TF1 *mypol = new TF1("mypol","[0]+[1]*x^[2]",0,2);
  LOgraph->GetHistogram()->SetTitle("Polynom [0]+[1]*x^[2]");
  LOgraph->Fit(mypol);
  c1->Print("3parampoly.gif");
}
```